Low Mach Mumber Modeling of Type Ia Supernovae

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The early stages of a Type Ia supernova are characterized by long periods of convection leading up to ignition and propagation of deflagration waves. Both the convection and the deflagration waves are low Mach number flows. In this presentation, we will introduce numerical models for the simulation of Type Ia supernovae based on a low Mach number formulation. The low Mach number formulation is based on a separation of scales between the fluid motion and the speed of sound in the fluid. This model analytically removes acoustic wave propagation while retaining the compressibility effects resulting from nuclear burning and ambient stratification. This formulation generalizes low Mach number models used in combustion and anelastic models used in atmospheric model to the conditions appropriate to a Type Ia supernova. The low Mach number formulation permits time steps that are controlled by the advective rather than acoustic time scales resulting in a substantial improvement in computational efficiency compared to a compressible formulation. Computational results illustrating application of the methodology will be presented.